

MEASUREMENT OF THE ABSOLUTE NP SCATTERING DIFFERENTIAL CROSS SECTION WITH A TAGGED NEUTRON BEAM AT INTERMEDIATE ENERGIES

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The neutron-proton scattering database at intermediate energies is plagued by experimental inconsistencies and cross section normalization difficulties [1]. This situation has led to an undesirable state of affairs, wherein the most sophisticated partial wave analyses of the data [2] ignore the vast majority of measured cross sections, the literature is filled with heated debates concerning experimental and theoretical methods [3], theorists propose radical “doctoring” to “salvage” allegedly flawed experiments [4], and one of the most fundamental parameters of meson-exchange theories of the nuclear force — the charged pion-nucleon-nucleon coupling constant — hangs in the balance [1–3]. I will describe the techniques and results of a new measurement performed with a very different approach from earlier experiments to settle the most worrisome discrepancies. The experiment involves a kinematically complete double-scattering measurement, carried out during the final year of operation of the Indiana University Cyclotron Facility’s Cooler ring. Neutrons of about 190 MeV were produced by the $^2\text{H}(p,n)2p$ reaction induced by a stored, electron-cooled proton beam in a deuterium gas jet target, permitting detection of the two low-energy recoil protons to tag and measure the four-momentum of each produced neutron. Energetic protons from np scattering induced in a secondary CH_2 target were detected (in coincidence with the tagging protons) in a forward detector array that spanned the entire c.m. angle range from 90 to 180°. A graphite target carefully matched in carbon density per unit area was frequently substituted for the CH_2 to permit an accurate background subtraction and reduce reliance on kinematic cuts to distinguish free from quasifree np scattering. These methods have allowed direct experimental determination of the absolute cross sections with a systematic uncertainty of order 2% and reliable measurement of the angular distribution shape for np backscattering. The results should settle the debate for np scattering and provide a good cross section standard for intermediate-energy neutron scattering.

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